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MAGNETIC AMPLIFIERS, INC.

Affiliate of GENERAL CERAMICS & STEATITE CORP.

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CONFIDENTIAL

INTERIM DEVELOPMENT REPORT

FOR

MAGNETIC AMPLIFIERS FOR

INFRARED DETECTOR SET

AN/SAR-2

This report covers the period 1 April 1953 to 30 June 1953

MAGNETIC AMPLIFIERS, INC
632 TINTON AVENUE
NEW YORK 55, N.Y.

NAVY DEPARTMENT BUREAU OF SHIPS ELECTRONICS DIVISION

CONTRACT NO. NObsr-57102 INDEX NO. NE-050722 28 July 1953

COPY NO. 3

MAGNETIC AMPLIFIERS, INC.

Abstract: This report summarizes the progress to date of work on a contract calling for a study to determine the feasibility of replacing the vacuum tube amplifiers of the AN/BAR-2 equipment with magnetic amplifiers.

1. PURPOSE: The purpose of this work is to determine the feasiblity of developing magnetic amplifier equipment to replace the vacuum tube amplifiers and circuits now used in the AN/BAR-2 equipment. The satisfactory replacement of the electronic equipment by magnetic amplifiers will effect great improvements in the reliability of the equipment and a reduction of the maintenance effort required. The incorporation of improved performance characteristics and the reduction of size and weight are additional objectives.

2. GENERAL FACTUAL DATA

2.1 PERSONNEL ENGAGED ON CONTRACT: The following is a list of the technical personnel engaged on this contract together with the man hours performed by each during the period covered by this report.

NAME	MAN HOURS
B. J. O'Neill	32
H. A. Goldsmith	32
H. Hors	34
L. Weissman	276
D. Rogers	28

3. MEASUREMENT PROCEDURES

3.1 TEST INSTRUMENTS: The following test instruments and equipment were used in evaluating the results included in this report:

(a) Krohn-Hite Oscillator, Model 410-A

(b) Ballantine V.T.V.M., Model 300

(c) Brush Recorder

(d) Oscillator-Driver, 400 cps.

(e) Noise Meter, Lab. Model NM-2

(f) Dumont Oscilloscope, Model 304-H

(g) Regulated Power Supply, 250 Volts, 80 Milliamperes, D.C.

3.2 TEST SET-UP: The test set-up used for core noise evaluation made in connection with this report is shown in figure 1.

3.3 MEASUREMENTS: Noise measurements were made with a laboratory constructed noise meter, the output being fed to a thermocouple galvanometer which indicated true RMS noise voltages. The output was monitored with an oscilloscope as a check against meter amplifier saturation. Meter calibration was checked periodically using the Krohn-Hite signal generator and the Ballantine V.T.V.M.

3.4 REFERENCES:

(1) Ferromagnetism - Bozorth, R.M. - D. Van Nostrant Co. (1951)

(2) Measurement of the Noise Figure of Low-Frequency Amplifiers - Saul Shenfeld-USL Report No. 154.

(3) Williams & Noble - Fundamental Limitations of the Second Harmonic Type Mag. Modulator - Proceedings Inst. of Electr. Engineering, Vol. 97

4. DETAIL FACTUAL DATA

4.1 DESCRIPTION OF PRESENT BAR-2 EQUIPMENT

4.1.1 GENERAL: The Infrared Detector Set AN/BAR-2 is a passive bearing finder system designed for installation on submarines to detect and obtain bearings of targets during periods of low visibility.

An optical system mounted on top of the periscope collects infrared radiation from a target and focuses it upon a sensitive bolometer element. The signal thus generated is amplified and presented as a visual indication of target bearing.

Provision is made for continuous 360° scanning or scanning of a limited sector only.

4.1.2 SIGNAL AMPLIFIER: The characteristics of the optical system are such that at the scanning speed used the maximum signal energy occurs at a frequency of approximately 30 cycles per second. This signal is fed into an amplifier which raises the output signal to the level necessary for utilization by the data presentation equipment. The amplifier is designed to operate with input signals from the 5 ohm bolometer as low as 10^{-18} watts. A maximum power gain of approximately 10^{18} is required. The amplifier must have an inherent noise level not exceeding twice that caused by the thermal noise of the input circuit resistance.

4.2 MAGNETIC AMPLIFIER SYSTEM

4.2.1 SIGNAL AMPLIFIER

4.2.1.1 SENSITIVITY AND NOISE CONSIDERATIONS: The minimum input power level at which an amplifier may operate is limited by the noise level. Noise sources limitating the low level operation of a magnetic amplifier are:

(a) Thermal Agitation: Noise of the input circuit which can be expected to contribute a noise powe of approximately 4×10^{-21} watts per cycle of band width at room temperature.

(b) Barkhausen Noise: Originating in the core material.

(c) Magnetrostriction of the Core Material: The effect of this phenomenon upon the noise level is not evident.

(d) Rectifiers: Various studies have indicated that crystal rectifiers are capable of providing a potent noise source at signal levels below 10^{-15} watts.

(e) External Fields

(f) Noise injected by signal source and/or measuring device.

(g) Noise injected by carrier source

(h) Microphonic Noise due to mechanical vibration

4.2.1.2 SUMMARY OF PREVIOUS INVESTIGATIONS: Studies made during previous periods indicated that the predominant noise source limiting the magnetic signal amplifier sensitivity was the core material itself. Some noise measurements were taken and calculations showed that the noie power in the control winding was about 8×10^{-14} watts. This figure checked with sensitivity measurements made previously.

4.2.1.3 NOISE INVESTIGATIONS DURING THE REPORT PERIOD: A core noise evaluation program was set up as outlined in a previous report. The core materials subjected to analysis were as follows:

Orthonol, 1 mil strip
Orthonol, 2 mil strip
Orthonol, 4 mil strip
Hymu 80, 3 mil strip
4750, 2 mil strip

All test cores were of wound toroidal construction. The measurement and test set-up is shown in figure 1. Data taken was corrected for actual core output by the factor of known gain of the noise meter. This gross output noise was then reduced to a common basis of RMS noise voltage per turn per cycle of band width so as to provide a noise figure which allowed comparison among the various materials. This data is tabulated in Table I and shown graphically in figure 2. From this data it is evident that different core materials produce noise levels which vary rather widely. In addition, the strip thickness is a factor in the noise level of a given core geometry.

4.7.2 SERVO SYSTEMS: In previous periods an investigation of the feasibility of applying magnetic amplifiers to two typical servo systems of the AN/BAR-2 equipment was carried out. The results of these studies, indicating the applicability of magnetic amplifiers to these systems were summarized in previous reports.

5.0 CONCLUSIONS

5.1 SIGNAL AMPLIFIER: The sensitivity of the signal amplifier is limited by two main factors:

(1) Rectifier Noise

(2) Core Noise

The first factor assumes a significant magnitude at input levels of less than 10^{-15} watts. The second factor is influenced by the choice of core materials and geometry and appears to limit the sensitivity

to about 10^{-16} watts at a carrier frequency of 400 cps. Detailed data on core noise will be presented in the final report on this study.

5.2 SERVO SYSTEMS: The applicability of magnetic amplifiers to two typical servo systems of the AN/BAR-2 equipment was studied during previous periods. These studies have been described in reports covering those intervals.

6.0 PROGRAM FOR NEXT INTERVAL: The investigations being carried out under this contract will be concluded and a final report giving a complete summary of the work performed will be issued during the next interval.

TABLE I, CORE NOISE DATA

Excitation Drive (ma)	RMS Noise Microvolts per Cycle of Band Width per Turn				
	4750	Hymu 80	Orthonol 2 Mil	Orthonol 1 Mil	Orthonol 4 Mil
5	.00029	.0100	.0292	.00318	.00528
10	.00292	.00415	.318	.0528	.0292
15	.0105	.00362	.134	.0528	.0372
20	.00715	.00380	.080	.0318	.0178
25	.0110	.0031	.068	.0318	.00925
30	.0150	.0033	.062	.0292	.0086

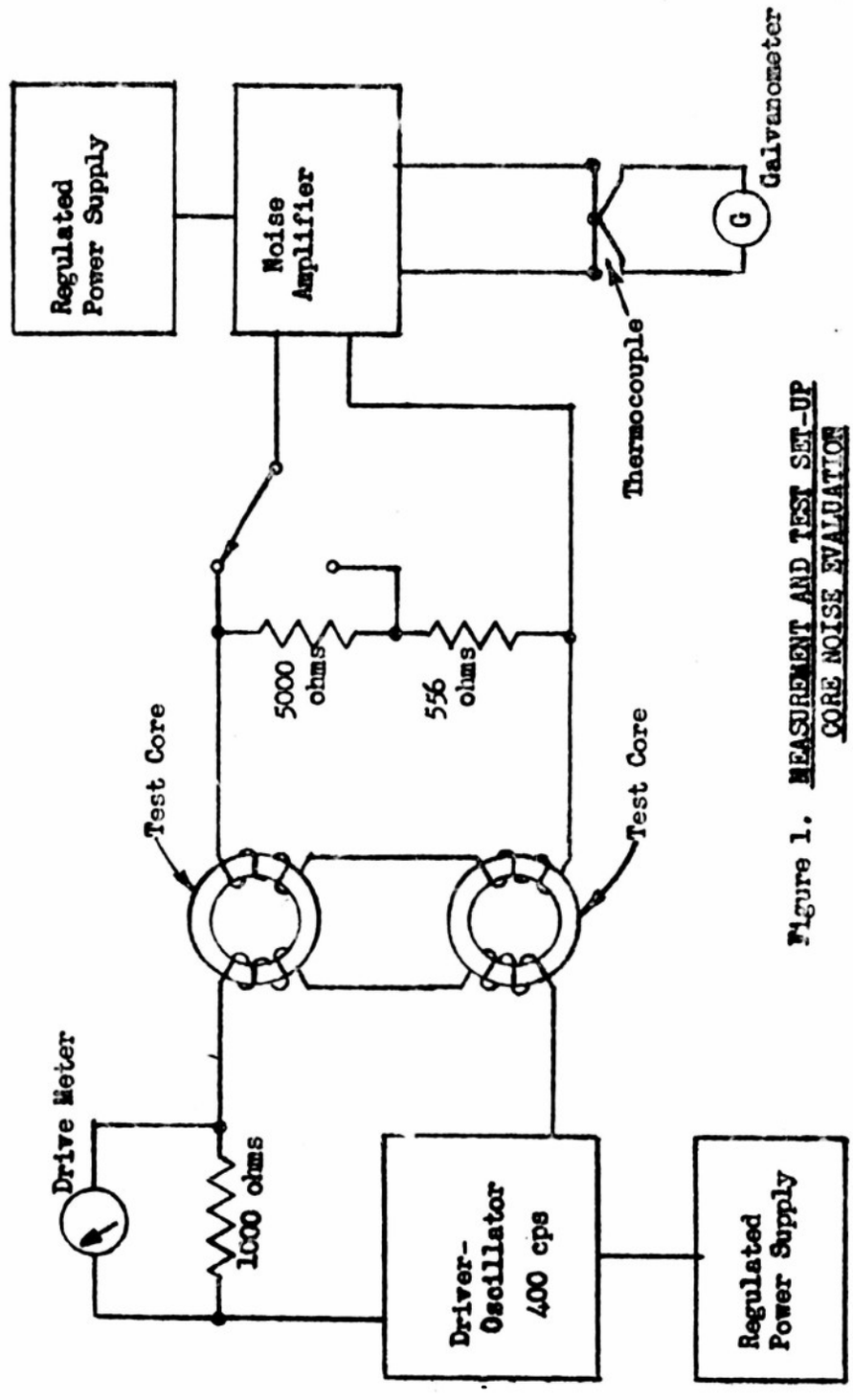

Figure 1. MEASUREMENT AND TEST SET-UP
CORE NOISE EVALUATION

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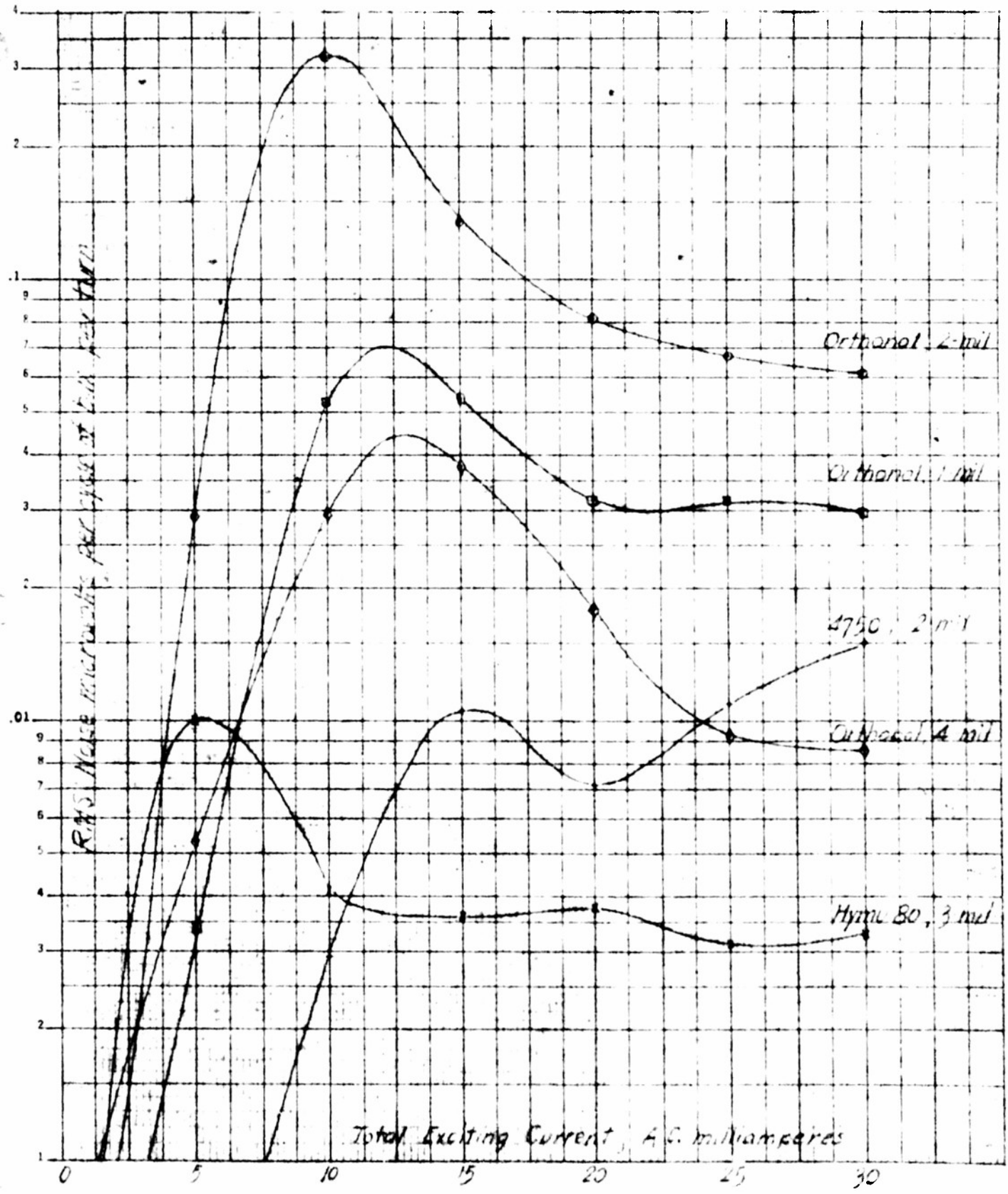

Figure 2. CORE NOISE vs. EXCITING CURRENT